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(54) Heat Dissipating Device in a Rack Device for Telecommunications Equipment

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SPECIFICATION

1. Title of the Invention

Heat Dissipating Device in a Rack Device for Communications Equipment

2. Patent Claims

1. A heat dissipating device in a rack device for communications equipment, said rack device for communications equipment being formed with a vertically stacked shelf unit assembly, having openings for printed circuit boards on the front surfaces of shelf units for housing multiple printed circuit boards, and formed with openings for ventilation on the top surfaces and bottom surfaces thereof, and having separation spaces for ventilation between vertically adjacent shelf units, where said assembly is housed within a cabinet provided with an inlet opening and an outlet opening for a ventilation fluid; characterized by

a cooling medium outflow passage for connecting to the outside is formed in the perpendicular direction through the back of said housed shelf unit assembly, and a separation plate is provided in the dividing space for ventilation of one of the shelf units at a position that is at a height lower than half of the total height of said stacked shelf unit assembly to divide vertically the main flow of the cooling flow that is to flow upwards through the entire area within said stacked shelf unit assembly so that each flows out to the outside in the upwards direction.

3. Detailed Explanation of the Invention

The present invention relates to heat dissipating devices in rack devices for communications equipment wherein shelf units, for mounting printed circuit boards, are housed in a plurality of ranks in a cabinet.

Typically, shelf units for communications equipment wherein a plurality of printed circuit boards are installed are stored in box-shaped cabinets, arrayed in a plurality of parallel rows in the front-back and left-right directions, for reasons such as protection from the outside, visual appearance, high product values, and the like. In such a case, a variety of heat-producing electronic components are mounted on a large number of printed circuit boards that are installed in each shelf unit, and it is necessary to maintain these electronic components at a

temperature at or below the guaranteed functioning temperature thereof, by dissipating, to the outside of the equipment, the heat generated by these electronic components, in order to ensure that these electronic components function optimally and in order to increase reliability. In recent years the packaging density of electronic circuitry and electronic components in these types of devices has increased, and because shelf units such as described above are housed in cabinets, there is a tendency of growing heat production within these devices, and thus thermal dissipation has become a critical and major problem.

Consequently, a variety of heat dissipation means for these types of devices have been proposed in the past. One well-known means is the forced air method for dissipating heat whereby the air is forcibly blown by the provision of a blower device at the top or the bottom of a cabinet, where cooling air is drawn through ventilation holes at the front surface and the bottom surface of the cabinet and said air is forcibly blown to the top outside of the cabinet, passing through each of the shelf units from the bottom to the top. However, even though heat dissipation is performed relatively well in this method, there are a variety of problems due to the installation of blowers. That is, there are cases wherein the blowers stop or fail due to unforeseen circumstances, and, in particular, more failures occur in many cases as the blowers near the limits to their useful lives (which are typically said to be between one and half years and two years). Consequently, because the blowing is interrupted when the blowers stop or fail in this way, the temperatures within the devices rise suddenly to exceed the guaranteed functional temperatures of the electronic components, which may cause impaired function or failure of the electronic components, which give rise to extremely troublesome problems, especially in systems such as electronic exchange equipment for telephoneservices, which operate 24 hours a day. Preventing this type of problem requires intense maintenance and inspections of the blowers, which is extremely labor-intensive. Moreover, while the provision of equipment to monitor for aberrant temperatures within the devices has also been considered, the power to the device is cut off by this monitoring equipment when an aberrant temperature occurs, which is not practical in electronic exchange equipment for telecommunications, in particular, because the communications circuits would be cut off in such an event. Because of this, forced air circulation using blowers in this way is rife with problems, along with being costly, and thus it is desirable to use blowers as little as possible.

Consequently, devices that dissipate heat by producing natural heat transfer by convection within the equipment without using blowers have also been proposed. Fig. 1 illustrates a conventional example of this type of equipment, and is a side-view cross-sectional diagram. In this figure, 1 is a cabinet, 1a and 1b are, respectively, the front cover and the back cover of the cabinet, 1c and 1d are respectively an air inlet opening and an air outlet opening, 3 is a shelf unit, 3a is a printed circuit board, 3b is a separation space, 5 is a heat dissipation plate, and 7 is an outflow passage. As shown in the figure, in this device the shelf units 3 are stacked into 6 ranks, where separation spaces are provided between shelf units that are adjacent in the vertical direction and heat dissipating plates 5, which divide the entire surfaces of the shelf units are provided in these spaces to form independent heat dissipating structures for each shelf unit 3. That is, the cooling air that flows in through the inlet opening 1c of the front cover 1a then flows into the shelf unit from the bottom surface and front surface of each shelf unit 3 and then strikes the heat dissipating plate 5 that has been heated through the production of heat of a heat-producing electronic component that is mounted on the printed circuit board 3a. Consequently, the air flows to the outside from the back of the shelf unit 3 through the outlet opening in the back of the separation space 3a, guided by the inclined surface of the heat dissipating plate 5, and then flows to the outside above and the outside behind the equipment through the outlet passage 7 and the back surface flow opening 1d to be diffused. In this way, the heat dissipation effect in this device is enhanced by the independent flow of the cooling air entering into each of the individual shelf units 3, and while this increases the heat dissipation effect, in practice the airflow in the upwards direction by the air that is heated within the shelf unit 3 experiences a great deal of resistance when it strikes the heat dissipating plates 5 so that the direction of flow changes suddenly, so that the flow towards the back is not smooth, but rather becomes stagnant at the top part of the shelf unit 3. Moreover, while a chimney effect is also formed in the outflow passage 7, this passage space is provided with an outlet opening 1d in the back cover 1b of the cabinet 1, so when one considers the outflow of heated air from these openings and the inflow of the outside air, the chimney effect is extremely small, and the heated air that should be flowing out in the upwards direction becomes stagnant, and the temperature is higher on the higher ranks of the shelf units. Consequently, there will be a large difference in temperatures between the upper part and the lower part within the cabinet 1 in this heat dissipating structure, and because the allowable

amount of heat that can be produced within the entire cabinet is set on the basis of the temperature at the top rank within the cabinet, which will be at the highest temperature, the amount of heat production that is acceptable in the rack device as a whole must be set to a small value, which adds unwanted constraints in terms of the quantities and types of electronic components that can be mounted. Consequently, a heat dissipating structure wherein the temperature is as uniform as possible in the cooling air across the entire cabinet from bottom to top is desirable.

Consequently, the object of the present invention is to provide a heat dissipating device in a rack device for communications equipment that can achieve improved heat dissipation efficiency and more uniform temperatures in the top and bottom parts of the cabinet through achieving smooth natural heat convection in the cooling air by means of structuring the vertically stacked shelf assembly so as to produce a chimney effect and further by means of producing the effect of a chimney in the entire cabinet by improving the heat dissipating structure.

In order to achieve this objective, the present invention provides a heat dissipating device in a rack device for communications equipment, said rack device for communications equipment being formed with a vertically stacked shelf unit assembly, having openings for printed circuit boards on the front surfaces of shelf units for housing multiple printed circuit boards, and formed with openings for ventilation on the top surfaces and bottom surfaces thereof, and having separation spaces for ventilation between vertically adjacent shelf units, where said assembly is housed within a cabinet provided with an inlet opening and an outlet opening for a ventilation fluid; wherein a cooling medium outflow passage for connecting to the outside is formed in the perpendicular direction through the back of said housed shelf unitassembly, and a separation plate is provided in the dividing space for ventilation of one of the shelf units at a position that is at a height lower than half of the total height of said stacked shelf unit assembly to divide vertically the main flow of the cooling air that is to flow upwards through the entire area within said stacked shelf unit assembly so that each flows out to the outside in the upwards direction.

The present invention will be explained in detail below based on an example of embodiment illustrated in the attached drawings.

Fig. 2 is a first example of embodiment as set forth in the present invention, in a partial cutaway external perspective view of a rack device for communications equipment. In the figure, a cabinet 11 is provided with an inlet opening 11b for cooling air in the front cover 11a thereof, where an air outlet opening 11c is provided at the top surface and where both side surfaces and the back surface are closed. The front cover 11a is normally formed as a door, formed so that the door can be opened to allow the shelf units 13 to be housed within the cabinet 11. These shelf units 13, as shown in Fig. 5 (II), accommodate a large number of printed circuit boards 13a, and have openings 13b on the front side thereof for inserting these printed circuit boards 13a, and are provided with ventilation openings 13c on the top surface and the bottom surface thereof (where the opening on the bottom surface is not shown in the figure). The ventilation openings 13c are provided in the locations on the top surface and the bottom surface corresponding to the gaps between adjacent printed circuit boards 13a in the form that allows easy flow of cooling air in the vertical direction. A frame 15' for forming a separation space 15 for ventilation is provided on the top surface of the shelf unit 13, and an inlet opening 15a and an outlet opening 15b for cooling air are formed on the front surface and the back surface, respectively. Consequently, in Fig. 2, a shelf unit assembly wherein shelf units 13, formed in this way, are stacked vertically in six ranks, and wherein there are separation spaces 15 for ventilation between mutually adjacent shelf units in the vertical direction, is stored in the cabinet 11. In this shelf unit assembly, a separation plate 17 as shown in Fig. 5 (I) is disposed at an angle towards the front in the position shown by the dashed-dotted line C in Fig. 5 (II) only within the separation space 15 for ventilation that is at a position that is lower than half of the height of the shelf unit assembly, or in other words, at only the separation space 15 for ventilation that is the second rank from the bottom, which is in the position that divides the height of the shelf unit assembly in the approximate ratio of 2:1 from above. Moreover, a gap is provided between the back surface of the aforementioned shelf unit assembly and the back surface of the cabinet 1 to form an outflow passage 19 for the air. Note that the inlet openings 11a for the air for cooling the cabinet 11 is provided corresponding to each of the printed circuit board insertion openings 13b on the front surfaces of each of these shelf units 13a, so that these printed circuit board insertion openings 13b also fulfill the role of inlet openings for the cooling air into the shelf units 13. Moreover, the printed circuit boards 13a housed in the shelf units 13 that are positioned vertically across separation spaces for ventilation are not provided at equal spacing between printed circuit boards, for reasons such as the heights of the electronic components that are mounted on the printed circuit boards, but rather are housed in a variety of conditions. Consequently, normally the

printed circuit boards 13a within shelf units 13 that are adjacent to each other in the vertical direction are not aligned with each other vertically. Because of this, if shelf units were stacked contiguous to each other without the provision of this dividing space 15 for ventilation, then, for example, the higher printed circuit board may be positioned in the space between lower printed circuit boards, which would impede the flow of air in the vertical direction between the shelf units. Consequently, this dividing space 15 for ventilation fulfills the role of a type of air buffer chamber, and has the effect of causing the air heated within the lower shelf unit to rise and mix with the air in the separation space 15, and at the same time, to draw cool air from the front surface so as to flow smoothly upward into the higher shelf unit.

Fig. 3 is a side view cross-sectional diagram of Fig. 2, illustrating the state of flow of the air for cooling. In the figure, the air for cooling that has entered from the front surface of the cabinet 11 flows within the shelf unit 13 as shown by the arrow B and is there heated by the [ILLEGIBLE] heat from the heat-producing electrical components, and then rises to flow into the separation space 15. The air that flows within the separation space 15 mixes with the air that has entered from the inlet opening 15a on the front surface of this space and then rises smoothly to flow into the higher shelf unit 13, while a portion of this air is divided and flows through the outlet opening 15b on the back surface to flow into the outflow passage 19. The air that flows within the outflow passage 19, being sealed within the back wall and the two sidewalls of the outflow passage rises smoothly to be discharged to the outside above the cabinet. Because the air for cooling flows extremely smoothly within the shelf unit assembly and within the outflow passage 19 in this way, the entirety of the cabinet 11 has the effect of a chimney. Consequently, a pressure differential is generated in the airflow between the inlet opening 11b and the outlet opening 11c sides of the cabinet 11. In other words, the inlet opening 11b side will be the positive pressure side, and the outlet opening 11c side will be the negative pressure side to produce an extremely excellent natural convection current of the air, with the effect that the duration of the stagnation of the air that flows into the cabinet will be extremely short when compared to that in the conventional example illustrated in the aforementioned Fig. 1, producing excellent heat dissipation. Moreover, the air within the shelf unit assembly is more heated as it rises, or in other words, becomes hotter along the distance of the rise, which reduces the heat dissipation effect in the shelf units 13 in the fifth and sixth rank. Consequently, focusing on the fact that an excellent heat dissipating effect can be obtained by preventing the increase in temperature of the cooling air in the shelf units 13 in the fifth and sixth ranks, a separation plate 17 is provided in one of the dividing spaces 15 for ventilation. The best heat dissipating effect is achieved by positioning this separation plate 17 below half of the total height of the shelf assembly, as described above, and preferably by dividing the assembly with a ratio of about 2:1 from above, or in other words, by providing within the dividing space 15 for ventilation at the second rank..

Fig. 4 is a side-view cross-sectional diagram of a second example of embodiment wherein the backs of the shelf unit assembly in Fig. 3 are placed against each other to form the heat dissipating structure. In this case, the outflow passage 19 is formed by the two side surfaces of the cabinet 11' and the backs of each of the shelf unit assembly, and otherwise this case is formed similarly to the first example of embodiment of Fig. 3, and provides a similar heat dissipation effect.

Fig. 6 is a line graph illustrating the results of measurements of the air temperatures within the shelves in a heat dissipation experiment performed under identical conditions for the first example of embodiment, as set forth in the present invention in Fig. 2 and Fig. 3, and for the conventional example in Fig. 1. In the figure, the numbers on the horizontal axis indicate the rank of the shelf unit, where 1 indicates the shelf unit on the first rank, 2 indicates the shelf unit on the second rank, and so forth. The vertical axis shows the temperature T, where the dashed-dotted line D that extends horizontally in the middle shows the guaranteed functional temperature (for example, 65° C.) for the electronic components, and the positions where the temperature measurements were performed were at the top part of each shelf. The curve (a) is the result of measurements in the conventional example shown in Fig. 1, where the temperatures were high, substantially exceeding the guaranteed functional temperature, in the shelf units in the fifth rank and the sixth rank. The curve (b) is the result of measurements in a state wherein the separation plate 17 in the first example of embodiment according to the present invention as shown in Fig. 2 and Fig. 3 has been removed for reference, and the temperatures are substantially lower throughout compared to the aforementioned curve (a), except in the first rank, and are below the guaranteed functioning temperatures in the shelf units in the fifth rank and the sixth rank, proving that the chimney effect is excellent. The curve (c) is the result of measurements in the aforementioned first example of embodiment with the separation plate 17 installed, where an extremely uniform temperature was achieved throughout the shelf units in all of the ranks from the first through

the sixth, illustrating strikingly the effect of providing the separation plate 17 in the separation space 15 for ventilation in the second rank. Note that the temperature in the shelf unit in the first rank being higher than the temperature in the second rank in all of curves (a), (b), and (c) is thought to be due to the structure wherein the cooling air flows in only from the front surface, without flowing in from the bottom surface, because the bottom surface is sealed in the shelf unit in the first rank. Of course, it is also possible to structure the units so as to enable the cooling air to flow in from the bottom surface as well.

4. Simple Explanation of Drawings

Fig. 1 is a side view cross-sectional diagram of a conventional example; Fig. 2 is a partial cutaway external perspective view of the first example of embodiment according to the present invention; Fig. 3 is a side view cross-sectional diagram of Fig. 2; Fig. 4 is a side view cross-sectional diagram of a second example of embodiment according to the present invention; Fig. 5 (I) and (II) are unit perspective diagrams of the separation plate 17 and the shelf unit 13, respectively, in Fig. 2 through Fig. 4; and Fig. 6 is a line diagram of the results of experimental measurements of the temperatures of the air in the shelf units in the first rank through sixth rank in the conventional example and the examples of embodiment according to the present invention.

11, 11': Cabinets
11a: Front cover of the cabinet
11b: Air inlet opening in the cabinet
11c: Air outlet opening in the cabinet
13: Shelf units
13a: Printed circuit board
13b: Front surface opening for inserting printed circuit boards into the shelf unit
13c: Top surface and bottom surface openings for ventilation in the shelf unit
15: Separation space for ventilation
15a: Front surface air inlet opening in the separation space for ventilation
15b: Back surface air outlet opening in the separation space for ventilation
17: Separation plate
19: Outflow passage

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Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Procedural Amendment

23 April 1982
To: Director General of the Patent Office: SHIMADA, Haruki

1.Case Identification:
Patent Application S56-084958
2: Title of the Invention
Heat Dissipating Device in a Rack Device for Communications Equipment
3. Amending Party
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5. Subject of the Amendment
(1) "Detailed Explanation of the Invention" in the Specification.
6. Details of the Amendment
(1) Amend the "Detailed Explanation of the Invention" in the Specification as written in the table below:

Page	Line	Prior to amendment	After amendment
2	10	high product values	commercial value
5	3	separation space	separation space 3b
10	5	inlet opening 11a	inlet opening 11b
10	5-6	shelf units 13a	shelf units 13
11	12	electrical components	electronic components